PPPL
PRINCETON PLASMA PHYSICS LABORATORY

Colloquium

The Path to Magnetic Fusion Energy: Crossing the Next Frontier

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Moving beyond ITER toward a compact magnetic fusion demonstration reactor (Demo) will require the integration of high plasma performance in steady-state with advanced methods for dissipating very high divertor heat-fluxes, while respecting strict limits on tritium retention. Expressing power exhaust requirements in terms of P_{heat}/R, future ARIES reactors are projected to operate with 60-200MW/m, Component Test Facilities (CTF) 40-50MW/m, and ITER 20-25MW/m. However, new and planned long-pulse experiments (such as EAST, JT60-SA, KSTAR, SST-1) are currently projected to operate at values of up to 16MW/m. The considerable gap between upcoming experiments and a CTF or fusion power plant motivates the proposal of a new experiment – the National High-power advanced-Torus eXperiment (NHTX) – whose mission is to study the integration of high-confinement, high-beta, long-pulse fully-non-inductive plasma operation with a fusion-relevant high-power plasma-boundary interface. Systems code studies find an optimal aspect ratio A=1.8-2 simultaneously maximizes the achievable P/R and non-inductive I_P (bootstrap + neutral beam current drive). The PPPL site power and TFTR test cell and neutral beams are well suited to the NHTX mission, and with P_{AUX} = 50MW and R_0=1m achieves P/R = 50MW/m. The resultant initial NHTX design point is A=1.8, R_0=1m, I_P=3-4MA, B_T=2T, κ=2.7-3, HH_{98Y} = 1.3, β_N=4.5, β_T=15%, f_{GW}=0.4-0.5, $f_{BS} \geq$ 65%, f_{NI} = 100%, τ_{pulse} up to 1000s, and T_{wall} ~ 600 °C for hydrogenic isotope retention studies using a range of plasma facing materials, including liquid metals. A highly flexible divertor coil set is a crucial design element which facilitates testing of many divertor geometries including an ITER-like divertor and a wide range of poloidal flux expansion = 3-30. TRANSP simulations of the beam-driven current, the role of other possible current-drive sources, and future engineering and physics analysis work will be discussed.

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4:15 P.M. (Refreshments at 4:00 P.M.)

Lyman Spitzer Building, M. B. Gottlieb Auditorium